Heterocyclic compound for stimulating or inducing the growth of the hair or eyelashes and/or slowing down their loss, composition comprising it and its uses

FIELD OF THE INVENTION

A subject-matter of the invention is the use of an effective amount of a heterocyclic compound and more especially of a phenylfuran, of a phenylthiophene or of a phenylpyrrole in a composition intended to induce and/or stimulate the growth of keratinous fibres, in particular human keratinous fibres, and/or to slow down their loss. Another subject-matter of the invention is such a composition. It additionally relates to a cosmetic treatment process and to novel heterocyclic compounds intended to stimulate the growth of keratinous fibres and/or to slow down their loss.

The human keratinous fibres to which the invention applies are in particular the hair, eyebrows, eyelashes, beard hairs, moustache hairs and pubic hairs. More especially, the invention applies to human hair and/or eyelashes.

In particular, the invention relates to a composition for caring for or making up the hair or eyelashes, comprising an effective amount of a heterocyclic compound possessing a phenyl radical, intended to increase their density and/or to improve their appearance.

BACKGROUND OF THE INVENTION

The growth of the hair and its renewal are mainly determined by the activity of the hair follicles and of their matrix environment. Their activity is cyclical and essentially comprises three phases, namely the anagen phase, the catagen phase and the telogen phase.

The anagen phase (active or growth phase), which lasts several years and during which the hair lengthens, is succeeded by a very short and transitory catagen phase, which lasts a few weeks. During this phase, the hair undergoes a change, the follicle atrophies and its implantation in the skin appears less and less deep.

The terminal phase or telogen phase, which lasts several months, corresponds to a resting phase of the follicle and the hair finishes by falling out. At the end of this resting period, a new follicle is regenerated there and another cycle recommences.

The hair is therefore continuously renewed and, of the approximately 150 000 individual hairs which make up the hair, approximately 10% are at rest and will be replaced in a few months.

The natural loss of the hair can be estimated, on average, at a few hundred hairs per day for a normal physiological state. This constant physical renewal process undergoes a natural change

during the course of ageing; the hairs become finer and their cycles shorter.

In addition, various causes can result in a significant, temporary or definitive, hair loss. The hair can be lost or detrimentally affected during recovery from pregnancy (post partum), during conditions of undernourishment or of dietary imbalances or during conditions of asthenia or of hormonal dysfunctioning, as may be the case during the course of or during recovery from the menopause. Hair can also be lost or detrimentally affected in connection with seasonal phenomena.

It may also be a matter of alopecia, which is essentially due to a disturbance of hair renewal which results, first, in an acceleration in the frequency of the cycles to the detriment of the quality of the hair and then of its amount. The successive growth cycles result in hair which is increasingly fine and increasingly short, which is gradually converted to an unpigmented down and which thus results in a gradual thinning of the head of hair. Areas are preferentially affected, in particular the temples or the front of the head in men, and, in women, a diffuse alopecia of the vertex is observed.

The term "alopecia" also covers a whole family of conditions of the hair follicle having, as a final consequence, partial or general permanent hair

loss. It is a matter more particularly of androgenic alopecia. In a significant number of cases, early hair loss takes place in genetically predisposed subjects; it is then a matter of androchronogenetic alopecia. This form of alopecia affects men in particular.

Furthermore, it is known that certain factors, such as hormonal imbalance, physiological stress or malnutrition, can accentuate the phenomenon.

In some dermatosis conditions of the scalp with an inflammatory nature, such as, for example, psoriasis or seborrhoeic dermatitis, hair loss can be greatly increased or can result in highly disrupted cycles of the follicles.

There has been a search for many years, in the cosmetic or pharmaceutical industry, for compositions which make it possible to eliminate or reduce alopecia and in particular to induce or stimulate hair growth or to decrease hair loss.

From this viewpoint, a large number of compositions comprising very diverse active principles, such as, for example, 2,4-diamino-6-piperidinopyrimidine 3-oxide or "minoxidil", disclosed in Patents 4 139 619 and US 4 596 812, or its numerous derivatives, such as those disclosed, for example, in Patent Applications EP 0 353 123, EP 0 356 271, EP 0 408 442, EP 0 522 964, EP 0 420 707, EP 0 459 890 and EP 0 519 819, have already been provided.

Clinical studies have demonstrated that $PGF_{2\alpha}$ analogues have the property of bringing about the growth of body hairs and eyelashes in man and animals (Murray A. and Johnstone M.D., 1997, Am. J. Opht., 124(4), 544-547). In man, tests carried out on the scalp have shown that a prostaglandin E_2 analogue (viprostol) has the property of increasing hair density (Roenig HH., 1988, *Clinic Dermatol.*, 6(4), 119-121).

Furthermore, Patent WO 98/33497 discloses pharmaceutical compositions comprising prostaglandins or prostaglandin derivatives intended to combat hair loss in man. Prostaglandins of the A_2, $F_{2\alpha}$ and E_2 type are mentioned as preferred.

However, prostaglandins are molecules with a very short biological half-life which act autocrinally or paracrinally, this reflecting the local and labile nature of the metabolism of prostaglandins (Narumiya S. *et al.*, 1999, *Physiol. Rev.*, 79(4), 1193-1226).

It thus appears important, to maintain and/or increase hair density in man, to retain the endogenous reserves of $PGF_{2\alpha}$ and of PGE_2 in the various compartments of the hair follicle or of its immediate cutaneous environment.

A solution which gives good results is the use of compounds which are inhibitors of lipoxygenase and/or inducers of cyclooxygenase for the purpose of promoting hair growth; one hypothesis is that the use

of such compounds directs the metabolism of the fatty acids towards the endogenous synthesis of prostaglandins in preference to other routes.

However, to further improve the results, it would be desirable to be able to prolong the activity of the prostaglandins involved in the growth and the preservation of the individual living hair.

Furthermore, it is well known that the programmes of differentiation of the keratinocytes of the epidermis and of the hair follicle are clearly different. Thus, it is known that the keratins of the hair shaft represents a family (Langbein et al., 2001, J. Biol. Chem., 276, 35123-35132) distinct from that expressed in the epidermis, that differentiation markers such as keratins K_1 and K_{10} are not expressed in the hair follicle and in particular in the outer sheath (Lenoir et al., 1988, Dev. Biol., 130, 610-620), that trichohyalin (O'Guin et al., 1992, J. Invest. Dermatol., 98, 24-32) and keratin K6irs (Porter et al., 2001, Br. J. Dermatol., 145, 558-568) are expressed in the hair follicle, in particular in the inner sheath, but not in the epidermis, and that cyclooxygenase type 1, while it is expressed in the epidermis, is not expressed in the keratinocytes of the hair follicle but in the dermal papilla (Michelet et al., 1997, J. Invest. Dermatol., 108, 205-209).

The Applicant has now demonstrated that an enzyme specifically involved in the decomposition of these prostaglandins is present in the dermal papilla of the individual hair, which is a determining compartment for the life of the individual hair. This is because the Applicant has now proved the presence of 15-hydroxyprostaglandin dehydrogenase (abbreviated to 15-PGDH) therein. In addition, it has shown that the inhibition of 15-PGDH has a beneficial effect on hair growth.

This is why the present invention relates to a composition for the care or treatment of human keratinous fibres and in particular hair fibres comprising at least one specific inhibitor of 15-hydroxyprostaglandin dehydrogenase and a physiologically acceptable medium.

15-PGDH is a key enzyme in the deactivation of prostaglandins, in particular of $PGF_{2\alpha}$ and of PGE_2, which are important mediators of the growth and survival of the individual hair. It corresponds to the EC 1.1.1.141 classification and is NAD+-dependent. It has been isolated from pig kidney; its inhibition by a thyroid hormone, triiodothyronine, at doses much greater than physiological doses has in particular been observed.

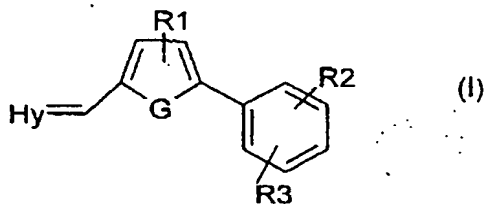
However, provision had never been made to use a 15-PGDH inhibitor for maintaining and/or increasing

the density of human keratinous fibres and in particular hair density and/or for reducing the heterogeneity in the diameters of keratinous fibres and in particular of head hairs in man. Increasing the density of keratinous fibres and in particular hair density is understood to mean increasing the number of keratinous fibres and in particular of head hairs per cm^2 of skin or scalp.

ACCOUNT OF THE INVENTION

The Applicant has found that some heterocyclic compounds and in particular some phenylfurans, phenylthiophenes or phenylpyrroles, which may or may not be salified, surprisingly possess a favourable activity in improving the density of human keratinous fibres, in particular hair fibres. Moreover, it has been found that these compounds are inhibitors of 15-hydroxyprostaglandin dehydrogenase.

A subject-matter of the present invention is thus the use, in particular the cosmetic use, of at least one heterocyclic compound of formula (I) or of one of its salts,



(I)

in which:

- Hy represents a heterocycle with 4, 5, 6 or 7 atoms optionally comprising at least one carbonyl functional group and/or one thiocarbonyl functional group, the said heterocycle optionally being substituted by at least one substituent chosen from a halogen, OR, SR, NRR', COR, CSR, NRCONR'R", C(=NR)R', C(=NR)NR'R", NRC(=NR')NR"R"', OCOR, COSR, SCOR, CSNRR', NRCSR', NRCSNR'R", COOR, CONRR', CF_3, CN, NRCOR', SO_2R', SO_2NRR' or $NRSO_2R'$ groups, saturated or unsaturated and linear or branched C_1-C_{20} alkyl radicals or saturated or unsaturated rings of 4 to 7 atoms optionally comprising at least one heteroatom, it being possible for these rings to be separate or fused, it being possible for the alkyl radicals and the rings, in addition, to be substituted, where R, R', R" and R"', which are identical or different, denote a hydrogen, a linear or branched C_1-C_{20} alkyl radical or an aryl radical which is optionally substituted;

- G represents O, S or NH;

- R_1, R_2 and R_3 represent, independently of one another, a hydrogen, a halogen, an OR_0, SR_0, NR_0R_0', COR_0, CSR_0, $NR_0CONR_0'R_0"$, $C(=NR_0)R_0'$, $C(=NR_0)NR_0'R_0"$, $NR_0C(=NR_0')NR_0"R_0"'$, $OCOR_0$, $COSR_0$, $SCOR_0$, $CSNR_0R_0'$, NR_0CSR_0', $NR_0CSNR_0'R_0"$, $COOR_0$, $CONR_0R_0'$, CF_3, NO_2, CN, NR_0COR_0', SO_2R_0', $SO_2NR_0R_0'$ or $NR_0SO_2R_0'$ group, a saturated or unsaturated and linear or branched C_1-C_{20} alkyl radical or at least one saturated or unsaturated ring

of 4 to 7 atoms optionally comprising at least one heteroatom, it being possible for the rings to be separate or fused, it being possible for the alkyl radicals and the rings, in addition, to be substituted, where R_0, R_0', R_0'' and R_0''', which are identical or different, denote a hydrogen, a linear or branched C_1-C_{20} alkyl radical or an aryl radical which is optionally substituted;

as agent for inducing and/or stimulating the growth of keratinous fibres, in particular human keratinous fibres, such as the eyelashes and hair of human beings, and/or slowing down their loss and/or increasing their density.

The invention also applies to the keratinous fibres of non-human mammals (dogs, horses or cats, for example).

The invention also relates to the cosmetic use of at least one heterocycle of formula (I) or of one of its salts in a cosmetic composition for caring for and/or making up human keratinous fibres in order to induce and/or stimulate their growth, to slow down their loss and/or to increase their density and/or to treat androgenic alopecia and to the use of at least one compound of formula (I) or of one of its salts in the preparation of a composition for caring for or treating human keratinous fibres intended to induce and/or stimulate the growth of the fibres and/or to

slow down their loss and/or to increase their density and/or to treat androgenic alopecia.

The human keratinous fibres to which the invention applies are in particular the hair, eyebrows, eyelashes, beard hairs, moustache hairs and pubic hairs. More especially, the invention applies to human hair and/or eyelashes.

The invention also relates to the cosmetic use of at least one heterocyclic compound of formula (I) or of one of its salts in a cosmetic composition for human hair care in order to reduce hair loss and/or to increase hair density. A further subject-matter of the invention is the use of at least one heterocyclic compound of formula (I) or of one of its salts in the preparation of a human hair composition intended to induce and/or stimulate the growth of the hair and/or to slow down hair loss and/or to increase hair density.

In particular, the invention relates to the cosmetic use of at least one heterocyclic compound of formula (I) or of one of its salts in a cosmetic composition for human hair care for treating alopecia of natural origin and in particular androchronogenetic alopecia or to the use of at least one heterocyclic compound of formula (I) or of one of its salts in the preparation of a human hair composition intended to treat alopecia of natural origin and in particular androgenic alopecia. Thus, this composition makes it

possible to keep the hair in good condition and/or to combat natural hair loss and more especially that of men.

A further subject-matter of the invention is the cosmetic use of at least one heterocyclic compound of formula (I) or of one of its salts in a cosmetic composition for caring for and/or for making up human eyelashes for inducing and/or stimulating the growth of the eyelashes and/or increasing their density and the use of at least one heterocyclic compound of formula (I) or of one of its salts in the preparation of a composition for caring for and/or treating human eyelashes intended to induce and/or stimulate the growth of the eyelashes and/or to increase their density. This composition thus makes it possible to keep the eyelashes in good condition and/or to improve their condition and/or their appearance.

Another subject-matter of the invention is a composition for caring for and/or making up keratinous fibres, in particular human keratinous fibres, comprising a physiologically acceptable medium and at least one heterocyclic compound of formula (I) or one of its salts.

Another subject-matter of the invention is the use of at least one heterocyclic compound of formula (I) or of one of its salts as inhibitor of 15-hydroxyprostaglandin dehydrogenase of the human

skin. Another subject-matter of the invention is the use of at least one heterocyclic compound of formula (I) or of one of its salts in the manufacture of a composition intended to treat disorders related to 15-hydroxyprostaglandin dehydrogenase, in particular in man.

Another subject-matter of the invention is a process for the cosmetic treatment of keratinous fibres (in particular hair or eyelashes) and/or of the skin from where the said fibres emerge, including the scalp and eyelids, intended in particular to stimulate the growth of human keratinous fibres and/or slow down their loss, characterized in that it consists in applying, to the keratinous fibres and/or the skin from where the said fibres emerge, a cosmetic composition comprising an effective amount of at least one compound of formula (I) or of one of its salts, in leaving this composition in contact with the keratinous fibres and/or the skin from where the said fibres emerge and optionally in rinsing the fibres and/or the said skin.

This treatment process exhibits the characteristics of a cosmetic process in so far as it makes it possible to improve the attractiveness of the keratinous fibres by giving them greater vigour and an improved appearance. In addition, it can be used daily for several months without a medical prescription.

More especially, a subject-matter of the present invention is a process for the cosmetic care of human hair and/or the human scalp for the purpose of improving their condition and/or their appearance, characterized in that it consists in applying, to the hair and/or the scalp, a cosmetic composition comprising an effective amount of at least one compound of formula (I) or one of its salts, in leaving this composition in contact with the hair and/or the scalp and optionally in rinsing the hair and/or the scalp.

Another subject-matter of the invention is a process for the cosmetic care of and/or for making up human eyelashes for the purpose of improving their condition and/or their appearance, characterized in that it consists in applying, to the eyelashes and/or eyelids, a mascara composition comprising at least one compound of formula (I) or one of its salts and in leaving this composition in contact with the eyelashes and/or eyelids. This mascara composition can be applied alone or as an undercoat of a conventional pigmented mascara and can be removed like a conventional pigmented mascara.

Another subject-matter of the invention is a composition for caring for or making up keratinous fibres comprising, in a physiologically acceptable medium, in particular a cosmetic medium, at least one compound of formula (I) or one of its salts and at

least one additional active principle which promotes the regrowth of human keratinous fibres and/or which limits the loss chosen from aminexil, FP receptor agonists and vasodilators and chosen more especially from aminexil, minoxidil, latanoprost, butaprost and travoprost.

Another subject-matter of the invention is the cosmetic use of at least one heterocyclic compound of formula (I) or of one of its salts in a cosmetic composition as agent for preserving the amount and/or the activity of prostaglandins in the hair follicle.

Another subject-matter of the invention is the use of at least one heterocyclic compound of formula (I) or of one of its salts in the manufacture of a composition intended to preserve the amount and/or the activity of prostaglandins in the hair follicle.

DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

In the continuation of the text, and unless expressly mentioned, the use of the term "compound of formula (I)" should be understood as meaning both the compound of formula (I) in the neutral, acidic or basic form and in the form of salts.

The term "15-hydroxyprostaglandin dehydrogenase inhibitor" is understood to mean a compound of formula (I) which is capable of inhibiting or reducing the activity of the enzyme 15-PGDH, in

particular in man, and/or is capable of inhibiting, reducing or slowing down the reaction catalysed by this enzyme.

According to an advantageous embodiment of the invention, the compound of formula (I) is a specific inhibitor of 15-PGDH; the term "specific inhibitor" is understood to mean an active principle which is not or only to a slight extent an inhibitor of the synthesis of prostaglandins, in particular of the synthesis of $PGF_{2\alpha}$ or PGE_2. According to a specific embodiment of the invention, the inhibitor of 15-PGDH is not or only to a slight extent an inhibitor of the synthesis of prostaglandins, in particular of the synthesis of $PGF_{2\alpha}$ or PGE_2. According to a specific embodiment of the invention, the inhibitor of 15-PGDH is not or only to a slight extent an inhibitor of prostaglandin synthase (PGF synthase).

This is because the Applicant has now found that PGF synthase is also expressed in the dermal papilla. The maintenance of an effective amount of prostaglandins at the site of action thus results from a complex biological equilibrium between the synthesis and the decomposition of these molecules. The exogenous contribution of compounds which inhibit catabolism will therefore be less effective if this activity is combined with inhibition of the synthesis of these prostaglandins.

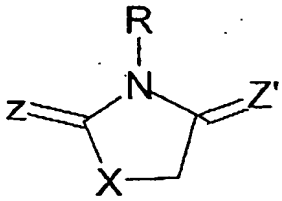
The compounds of formula (I), which may or may not be salified, advantageously exhibit an inhibitory activity for 15-PGDH which is greater than the activity inhibiting PGF synthase. In particular, the ratio of the inhibitory activity for PGF synthase to the inhibitory activity for 15-PGDH for a given concentration, which activities are determined in particular by the concentrations which inhibit 50% of the enzymatic activity of PGF synthase IC_{50}sf and of 15-PGDH IC_{50}dh respectively, is at least greater than 1 and in particular at least 3:1, advantageously greater than or equal to 5:1. The preferred compounds of the invention exhibit an IC_{50}sf/IC_{50}dh ratio of greater than or equal to 10:1.

"At least one" according to the invention means one or more (2, 3 or more). In particular, the composition can comprise one or more compounds of formula (I). This or these compounds can be cis or trans or Z or E isomers or a mixture of cis/trans or Z/E isomers. They can also be in the tautomeric form. In particular, the heterocycle Hy can be in the cis or trans or Z or E position and better still in the Z position of the adjacent double bond. This or these compounds can be enantiomers and/or diastereoisomers or a mixture of these isomers, in particular a racemic mixture.

The term "alkyl radical" is understood to mean, within the meaning of the invention, a hydrocarbonaceous radical which can be saturated or unsaturated and linear or branched. The alkyl radical preferably comprises from 1 to 10 carbon atoms. Mention may be made, as example of an alkyl radical which can be used in the invention, of the methyl, ethyl, isopropyl, n-butyl, *tert*-butyl, n-hexyl, 2-ethylhexyl, ethylene or propylene radicals. This radical can optionally be substituted, in particular by OR_0, with R_0 being H or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, for example C_1-C_5, alkyl radical.

According to the invention, the heteroatom or heteroatoms of Hy can be O, N, S, P, Si or Se and in particular O, N or S. The heterocycle Hy can be saturated or unsaturated. In addition, it can comprise 4, 5, 6 or 7 atoms and one or more carbonyl or thiocarbonyl functional groups or both, the carbon of these functional groups forming part of the heterocycle.

In a specific embodiment of the invention, Hy represents an aromatic ring with 5 atoms comprising, as heteroatom, sulphur, nitrogen and their combinations. In addition, this heterocycle Hy comprises one or two carbonyl groups, the carbon of which groups forms part of the heterocycle. By way of example, this heterocycle exhibits the following formula (II):



(II)

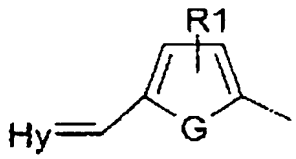
where Z, Z' and X independently represent S or O and R represents H or a saturated, linear or branched, C_1-C_{10} alkyl radical. X can also represent NH. Advantageously, Z and Z' represent oxygen, which corresponds to a 1,3-thiazolidine-2,4-dione ring.

According to the invention, the rings employed as substituent (S_1) comprise from 4 to 7 atoms and better still from 5 to 6 atoms. They can be saturated or unsaturated and can optionally comprise one or more heteroatoms, such as S, N, O or their combinations. Furthermore, these rings can be alone or fused to another ring with the same or different chemical structure. When they are fused, they form condensed rings.

Mention may be made, as saturated hydrocarbonaceous rings which can be used, of the cyclopentyl or cyclohexyl radical and mention may be made, as unsaturated hydrocarbonaceous rings, of the cyclohexenyl or phenyl ring. Mention may be made, as fused hydrocarbonaceous rings, of the naphthyl radical. Mention may be made, as heterocycle, of the pyridine, piperidine, morpholine, pyrrole, furan or thiazole rings. In addition, these rings can be substituted by

one or more substituents having the definition indicated above for R or R_0.

According to the invention, the compounds of formula (I) are in the isolated form, that is to say nonpolymeric form. They are phenylfurans, phenylthiophenes or phenylpyrroles. In addition, R_1 can be situated in the 3- or 4-position, G being regarded as the 1-position of the heterocycle with 5 atoms. Furthermore, R_2 and R_3 can be situated in any position of the phenyl ring carrying them and in particular in the para- or meta-position with regard to the following part (A):



(A)

Preferably, R_1 represents a hydrogen atom.

Advantageously, at least one of the R_2 and R_3 groups represent CF_3, OR_0 or $COOR_0$ with R_0 being H or a saturated or unsaturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical. Mention may be made, as example of alkyl radical which can be used, of methyl, ethyl, tert-butyl, isopropyl, n-butyl or n-hexyl. In particular, $COOR_0$ represents COOH or $COOCH_2$-CH_3. In addition, OR_0 represents in particular OH or OCH_3. In particular, R_2 represents COOH or OH and R_3 represents H; R_2 represents $COOCH_2$-CH_3 and R_3 represents H; or R_2 and R_3 represent CF_3 or OCH_3.

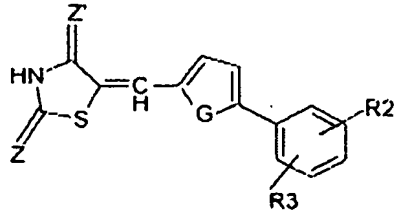
The term "salts of compound of formula (I)" is understood to mean, according to the invention, the organic or inorganic and single or double salts of a compound of formula (I).

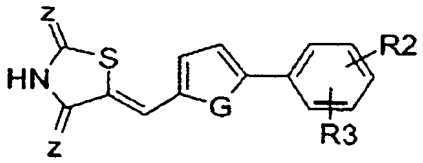
Mention may be made, as inorganic salts which can be used according to the invention, of: single or double sodium or potassium salts and salts of zinc (Zn^{2+}), of calcium (Ca^{2+}), of copper (Cu^{2+}), of iron (Fe^{2+}), of strontium (Sr^{2+}), of magnesium (Mg^{2+}), of ammonium and of manganese (Mn^{2+}); hydroxides, carbonates, halides (such as chlorides), sulphates, nitrates or phosphates. Preferably, the salt is a sodium salt.

The organic salts which can be used according to the invention are, for example, triethanolamine, monoethanolamine, diethanolamine, hexadecylamine, N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine or tris(hydroxymethyl)aminomethane salts.

According to a specific embodiment of the invention, the heterocyclic compounds to which the invention applies exhibit the following formula (III) and better still the following formula (IIIa) or the corresponding salt (mono- or disalt) form:

(III)

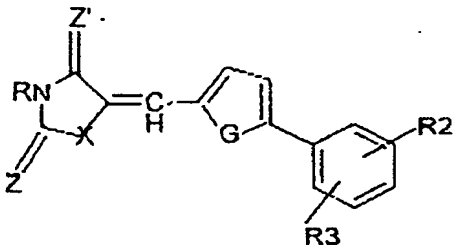




(IIIa)

in which Z, Z' and G independently represent O or S; and at least one of the R_2 and R_3 groups represent CF_3, OR_0 or $COOR_0$ with R_0 being H or a saturated or unsaturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical.

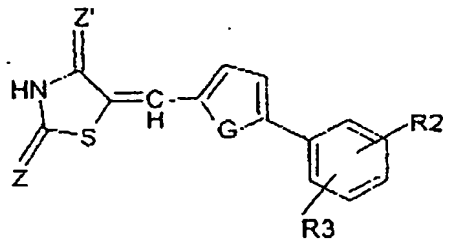
Another subject-matter of the invention is a novel heterocyclic compound of following formula (IV) or in the form of one of its salts, exhibiting in particular the property of inhibiting 15-PGDH and/or of preserving the amount and/or the activity of prostaglandins, in particular in the human hair follicle:



in which Z, Z' and G independently represent O or S; X represents O, NH or S; R represents hydrogen or a saturated, linear or branched, C_1-C_{10} alkyl radical; and at least one of the R_2 and R_3 groups represent a hydrogen, CN, NO_2, CF_3, a phenyl, OR_0 or $COOR_0$ radical or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical optionally substituted by OR_0 with R_0 being H or a saturated, linear or branched, C_1-C_{20},

better still C_1-C_{10}, alkyl radical, provided that, when X = S and Z = Z' = G or Z ≠ Z', then R_2 and R_3 are other than COOH.

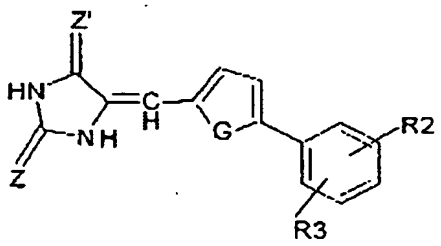
According to a specific embodiment, the heterocyclic compound exhibits the following formula (V) or a corresponding salt:



in which Z, Z' and G independently represent O or S; and at least one of the R_2 and R_3 groups represent phenyl, NO_2, CF_3, OR_0, OR_0, $COOR_0$ or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical optionally substituted by OR_0 with R_0 being H or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical, provided that, when Z = Z' = G or Z ≠ Z', then R_2 and R_3 are other than COOH.

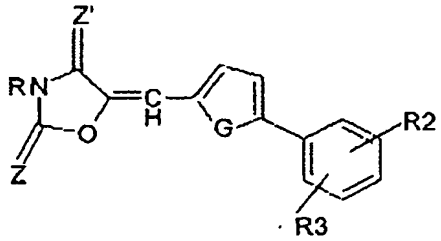
Advantageously, when Z = Z' = G, at least one of the R_2 and R_3 groups represents CF_3, OR_0 or $COOR_0$ with R_0 being a saturated, linear or branched, C_1-C_{10}, better still C_1-C_5, alkyl radical. According to another preferred embodiment of the invention, when Z = Z' and are different from G, at least one of the R_2 and R_3 groups represents CF_3 or $COOR_0$ with R_0 being H.

According to another embodiment of the invention, the heterocyclic compound exhibits the following formula (VI) or a corresponding salt form:



in which Z, Z' and G independently represent O or S; and at least one of the R_2 and R_3 groups represent a hydrogen, CN, CF_3, NO_2, OR_0, $COOR_0$ or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical optionally substituted by OR_0 with R_0 being H or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical.

According to another embodiment of the invention, the heterocyclic compound exhibits the following formula (VII) or the corresponding salt form:



in which Z, Z' and G independently represent O or S; R represents a saturated, linear or branched, C_1-C_{10} alkyl radical; and at least one of the R_2 and R_3 groups represent a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical, NO_2 or OR_0 with R_0

being H or a saturated, linear or branched, C_1-C_{20}, better still C_1-C_{10}, alkyl radical.

Preferably, the heterocyclic compound of the invention is in the Z form.

To the knowledge of the Applicant, no document of the prior art discloses or suggests that the heterocyclic compounds of formula (I) or one of their salts have the property of inducing and/or stimulating the growth of human keratinous fibres and in particular of the hair and eyelashes and/or slowing down their loss, or that these compounds can be used topically to increase the density of human keratinous fibres and more especially that of the hair and eyelashes.

The compounds of formula (I) or their salts can be manufactured in a known way as disclosed in the document WO 01/066541. The compounds of formula (I) are solid at ambient temperature.

The effective amount of a compound of formula (I) or of one of its salts corresponds to the amount necessary to obtain the desired result (namely, to increase the density of keratinous fibres and in particular of the hair and eyelashes or to promote their growth). A person skilled in the art is therefore in a position to evaluate this effective amount, which depends on the nature of the compound used, on the

person to which it is applied and on the time of this application.

In the continuation of the text, unless otherwise indicated, the amounts of the various ingredients of the composition are given as percentage by weight with respect to the total weight of the composition.

To give an order of magnitude, according to the invention, the compound of formula (I) or one of its salts or a mixture of compounds of formula (I) and/or of their salts can be used in an amount representing from 10^{-3}% to 10% of the total weight of the composition and preferably in an amount representing from 10^{-3}% to 5% and better still from 10^{-2}% to 2% of the total weight of the composition, for example from 0.5 to 2%.

The composition of the invention can be for cosmetic or pharmaceutical use. Preferably, the composition of the invention is for cosmetic use. Consequently, the composition should comprise a physiologically acceptable medium which is non-toxic and which is capable of being applied to human skin, including the scalp and eyelids, and to human keratinous fibres. The term "cosmetic" is understood to mean, within the meaning of the invention, a composition with a pleasant appearance, smell and feel.

The compound of formula (I), which may or may not be salified, can be used in a composition which has to be ingested, injected or applied to the skin or to keratinous fibres (over any cutaneous region or all of the fibres to be treated).

According to the invention, the compound of formula (I) or one of its salts can be used orally in an amount of 0.1 to 300 mg per day, for example of 5 to 10 mg/day.

A preferred composition of the invention is a composition for cosmetic use and in particular for topical application to the skin and keratinous fibres and more especially to the scalp, hair and eyelashes.

Consequently, another subject-matter of the invention is a composition for caring for or making up keratinous fibres, in particular a haircare or mascara composition, for topical application comprising a physiologically acceptable medium and an effective amount of at least one compound of formula (I) or of one of these salts, as described above.

This composition can be provided in any known dosage form which is suited to the method of use.

For topical application to the skin, the composition can have the form of an aqueous, alcoholic or aqueous/alcoholic solution or suspension or of an oily suspension, of an emulsion with a more or less fluid consistency and in particular a liquid or semi-

liquid consistency, obtained by dispersion of a fatty phase in an aqueous phase (O/W) or vice versa (W/O), of an (O/W) or (W/O) solid emulsion, of an aqueous, aqueous/alcoholic or oily gel which is more or less fluid or solid, of a free or compact powder to be used as is or to be incorporated in a physiologically acceptable medium, or also of microcapsules or microparticles, or of vesicular dispersions of ionic and/or nonionic type.

It is also possible to envisage a composition in the form of a foam or in the form of a spray or aerosol then comprising a pressurized propellant.

It can thus be provided in the form of a lotion, serum, milk, O/W or W/O cream, gel, ointment, pomade, powder, balm, patch, impregnated pad, cake or foam.

In particular, the composition for application to the scalp or hair can be provided in the form of a hair care lotion, for example for daily or twice-weekly application, of a shampoo or of a hair conditioner, in particular for twice-weekly or weekly application, of a liquid or solid soap for cleaning the scalp, for daily application, of a product for shaping the hairstyle (lacquer, hairsetting product, styling gel), of a treatment mask, of a cream or of a foaming gel for cleaning the hair. It can also be provided in

the form of a hair dye or mascara to be applied with a brush or comb.

Furthermore, for application to the eyelashes or body hairs, the composition to which the invention applies can be provided in the form of a pigmented or nonpigmented mascara, to be applied with a brush to the eyelashes or alternatively to the beard or moustache hairs.

For a composition for use by injection, the composition can be provided in the form of an aqueous lotion or of an oily suspension. For use by the oral route, the composition can be provided in the form of capsules, of granules, of syrups to be taken orally or of tablets.

According to a specific embodiment, the composition according to the invention is provided in the form of a hair cream or lotion, of a shampoo, of a hair conditioner, of a hair mascara or of a mascara for the eyelashes.

The amounts of the various constituents of the composition according to the invention are those generally used in the fields under consideration. In addition, these compositions are prepared according to conventional methods.

When the composition is an emulsion, the proportion of the fatty phase can range from 2% to 80% by weight and preferably from 5% to 50% by weight with

respect to the total weight of the composition. The aqueous phase is adjusted according to the content of fatty phase and of compound(s) (I) and according to the content of possible additional ingredients, in order to obtain 100% by weight. In practice, the aqueous phase represents from 5 to 99.9%.

The fatty phase can comprise fatty or oily compounds which are liquid at ambient temperature (25°C) and atmospheric pressure (760 mmHg), generally known as oils. These oils may or may not be compatible with one another and may form a macroscopically homogeneous liquid fatty phase or a two- or three-phase system.

The fatty phase can, in addition to the oils, comprise waxes, gums, lipophilic polymers, or "pasty" or viscous products comprising solid parts and liquid parts.

The aqueous phase comprises water and optionally an ingredient miscible in any proportion with water, such as lower C_1 to C_8 alcohols, for example ethanol or isopropanol, polyols, such as propylene glycol, glycerol or sorbitol, or else acetone or ether.

The emulsifiers and coemulsifiers used to produce a composition in the form of an emulsion are those generally used in the cosmetic and pharmaceutical fields. In addition, their nature depends on the sense of the emulsion. In practice, the emulsifier and

optionally the coemulsifier are present in the composition in a proportion ranging from 0.1% to 30% by weight, preferably from 0.5 to 20% by weight and better still from 1 to 8%. In addition, the emulsion can comprise lipid vesicles and in particular liposomes.

When the composition is in the form of an oily solution or gel, the fatty phase can represent more than 90% of the total weight of the composition.

Advantageously, for a hair application, the composition is an aqueous, alcoholic or aqueous/alcoholic solution or suspension and better still a water/ethanol solution or suspension. The alcohol fraction can represent from 5 to 99.9% and better still from 8 to 80%.

For a mascara application, the composition of the invention is a wax-in-water or wax-in-oil dispersion, a gelled oil or an aqueous gel, with or without pigment.

The composition of the invention can comprise, in addition, other ingredients generally used in the fields concerned chosen from solvents, thickeners or gelling agents for the aqueous phase or for the oily phase, colouring materials which are soluble in the medium of the composition, solid particles of the filler or pigment type, antioxidants, preservatives, fragrances, electrolytes, neutralizing agents, film-forming polymers, UV blocking agents, such

as sunscreens, cosmetic and pharmaceutical active principles with a beneficial effect on the skin or keratinous fibres, other than the compounds of formula (I), or their mixtures. These additives can be present in the composition according to the amounts generally used in the cosmetic and dermatological field and in particular in a proportion of 0.01 to 50% of the total weight of the composition and better still of 0.1 to 20% and, for example, of 0.1 to 10%. These additives, depending on their nature, can be introduced into the fatty phase, into the aqueous phase and/or into the lipid vesicles and in particular liposomes.

Of course, a person skilled in the art will take care to choose the possible additional additives and/or their amounts so that the advantageous properties of the composition according to the invention, namely the inhibition, in particular specific inhibition, of 15-PGDH and in particular the increase in the density of keratinous fibres (hair or eyelashes), are not, or not substantially, detrimentally affected by the envisaged addition.

Mention may be made, as solvents which can be used in the invention, of lower C_2 to C_8 alcohols, such as ethanol or isopropanol, propylene glycol and certain light cosmetic oils, such as C_6 to C_{16} alkanes.

Mention may be made, as oils which can be used in the invention, of oils of mineral origin

(liquid petrolatum, hydrogenated isoparaffin), oils of vegetable origin (liquid fraction of karite butter, sunflower oil, apricot oil, fatty alcohol or fatty acid), oils of animal origin (perhydrosqualene), synthetic oils (fatty acid esters, purcellin oil), silicone oils (phenyltrimethicone, linear or cyclic polydimethylsiloxane) and fluorinated oils (perfluoropolyethers). Mention may be made, as waxes, of silicone waxes, beeswax, rice wax, candelilla wax, carnauba wax, paraffin wax or polyethylene wax.

Mention may be made, as emulsifiers which can be used in the invention, of, for example, glyceryl stearate or laurate, sorbitol stearates or oleates, alkyl dimethicone copolyols (with alkyl $\geq$ 8) and their mixtures for a W/O emulsion. Use may also be made of polyethylene glycol monostearate or monolaurate, polyoxyethylenated sorbitol stearate or oleate, dimethicone copolyols and their mixtures for an O/W emulsion.

Mention may be made, as hydrophilic gelling agents which can be used in the invention, of carboxyvinyl polymers (carbomer), acrylic copolymers, such as acrylate/alkyl acrylate copolymers, polyacrylamides, polysaccharides, such as hydroxypropylcellulose, natural gums and clays and mention may be made, as lipophilic gelling agents, of modified clays, such as bentones, metal salts of fatty

acids, such as aluminium stearates, hydrophobic treated silica, ethylcellulose or their mixtures.

The composition can additionally comprise a cosmetic or pharmaceutical active principle other than the compounds of formula (I) which can be hydrophilic and is chosen from proteins, protein hydrolysates, amino acids, polyols, urea, allantoin, sugars and sugar derivatives, water-soluble vitamins, plant extracts (those of Iridaceae or of soya) and hydroxy acids, such as fruit acids or salicylic acid; or lipophilic and is chosen from retinol (vitamin A) and its derivatives, in particular ester (retinol palmitate), tocopherol (vitamin E) and its derivatives, in particular ester (tocopherol acetate), essential fatty acids, ceramides, essential oils, salicylic acid derivatives, such as 5-(n-octanoyl)salicylic acid, esters of hydroxy acids, phospholipids, such as lecithin, or their mixtures.

According to a specific embodiment of the invention, the compound of formula (I) or one of its salts can be combined with at least one additional active compound which promotes the regrowth and/or which limits the loss of keratinous fibres (hair, eyelashes). These additional compounds are chosen in particular from lipoxygenase inhibitors, such as disclosed in EP 0 648 488, bradykinin inhibitors, disclosed in particular in EP 0 845 700, prostaglandins and their derivatives, in particular those disclosed in

WO 98/33497, WO 95/11003, JP 97-100091 or JP 96-134242, prostaglandin receptor agonists or antagonists, nonprostanoic prostaglandin analogues, such as disclosed in EP 1 175 891 and EP 1 175 890, WO 01/74307, WO 01/74313, WO 01/74314, WO 01/74315 or WO 01/72268, or their mixtures.

Mention may be made, as other additional active agents which promote the growth of keratinous fibres (in particular of the hair) and/or which limit their loss which can be present in the composition according to the invention, of vasodilators, antiandrogens, cyclosporins and their analogues, antimicrobials and antifungals, anti-inflammatories or retinoids, alone or as a mixture.

The vasodilators which can be used are in particular potassium channel agonists, including minoxidil and the compounds disclosed in Patents US 3 382 247, 5 756 092, 5 772 990, 5 760 043, 5 466 694, 5 438 058 or 4 973 474, cromakalim, nicorandil and diaxozide, alone or in combination.

The antiandrogens which can be used include in particular steroidal or nonsteroidal inhibitors of 5α-reductase, such as finasteride and the compounds disclosed in US 5 516 779, cyprosterone acetate, azelaic acid, its salts and its derivatives and the compounds disclosed in US 5 480 913, flutamide, oxendolone, spironolactone, diethylstilbestrol and the

compounds disclosed in Patents US 5 411 981, 5 565 467 and 4 910 226.

The antimicrobial or antifungal compounds can be chosen from selenium derivatives, octopirox, ketoconazole, triclocarban, triclosan, zinc pyrithione, itraconazole, asiatic acid, hinokitiol, mipirocin, tetracyclines, in particular erythromycin and the compounds disclosed in EP 0 680 745, clinycin hydrochloride, benzoyl peroxide or benzyl peroxide, minocyclin and the compounds belonging to the class of the imidazoles, such as econazole, ketoconazole or miconazole or their salts, or nicotinic acid esters, including in particular tocopherol nicotinate, benzyl nicotinate and C_1-C_6 alkyl nicotinates, such as methyl nicotinate or hexyl nicotinate.

The anti-inflammatories can be chosen from steroidal anti-inflammatories, such as glucocorticoids or corticosteroids (for example: hydrocortisone), and nonsteroidal anti-inflammatories, such as glycyrrhetinic acid and α-bisabolol, benzydamine, salicylic acid and the compounds disclosed in EP 0 770 399, WO 94/06434 and FR 2 268 523.

The retinoids can be chosen from isotretinoin, acitretin and tazarotene.

Mention may be made, as other active compounds for promoting the growth and/or limiting the loss of the hair which can be used in combinations with

the compound of formula (I), of aminexil, 6-O-[(9Z,12Z)-octadeca-9,12-dienoyl]hexapyranose, benzalkonium chloride, benzethonium chloride, phenol, oestradiol, chlorpheniramine maleate, chlorophyllin derivatives, cholesterol, cysteine, methionine, menthol, peppermint oil, calcium panthotenate, panthenol, resorcinol, protein kinase C activators, glycosidase inhibitors, glycosaminoglycanase inhibitors, pyroglutamic acid esters, hexosaccharidic acid or acylhexosaccharic acid, aryl-substituted ethylenes, N-acylated amino acids, flavonoids, ascomycin derivatives and analogues, histamine antagonists, saponins, proteoglycanase inhibitors, oestrogen agonists and antagonists, pseudopterins, cytokines and growth factor promoters, IL-1 or IL-6 inhibitors, IL-10 promoters, TNF inhibitors, benzozphenones and hydantoin, retinoic acid; vitamins, such as vitamin D, analogues of vitamin B12 and panthotenol; triterpenes, such as ursolic acid and the compounds disclosed in US 5 529 769, US 5 468 888 or US 5 631 282; antipruritic agents, such as thenaldine, trimeprazine or cyproheptadine; agents for combating parasites, in particular metronidazole, crotamiton or pyrethroids; calcium antagonist agents, such as cinnarizine, diltiazem, nimodipine, verapamil and nifedipine; hormones, such as oestriol or its analogues, thyroxine and its salts, or progesterone; FP

receptor (receptor to prostaglandins of the F type) agonists, such as latanoprost, bimatroprost, travoprost or unoprostone; and their mixtures.

Advantageously, the composition according to the invention will comprise at least one 15-PGDH inhibitor as defined above and at least one prostaglandin or one prostaglandin derivative, such as, for example, prostaglandins of the 2 series, including in particular $PGF_{2\alpha}$ and PGE_2, in the salt or ester form (example, the isopropyl esters), their derivatives, such as 16,16-dimethyl-PGE_2, 17-phenyl-PGE_2, 16,16-dimethyl-$PGF_{2\alpha}$ or 17-phenyl-$PGF_{2\alpha}$, or prostaglandins of the 1 series, such as 11-deoxy-prostaglandin E_1 or 1-deoxyprostaglandin E_1, in the salt or ester form, their analogues, in particular latanoprost, travoprost, bimatoprost, fluprostenol, cloprostenol, viprostol, butaprost, misoprostol or unoprostone, their salts or their esters.

Preferably, the composition comprises at least one nonprostanoic agonist of the EP2 and/or EP4 receptors, in particular as disclosed in EP 1 175 892.

It is also possible to envisage that the composition comprising at least the compound of formula (I), which may or may not be salified, is in the liposomed form, such as disclosed in particular in the document WO 94/22468. Thus, the compound encapsulated

in the liposomes can be delivered selectively to the hair follicle or the base of the eyelash.

The composition according to the invention can be applied to the areas of the scalp and hair of an individual which are suffering from alopecia and can optionally be left in contact for several hours and can optionally be rinsed.

It is possible, for example, to apply the composition comprising an effective amount of a compound of formula (I), which may or may not be salified, in the evening, to keep this composition in contact overnight and optionally to clean the fibres, such as to shampoo, on the following morning. These applications can be repeated daily for one or more months, depending on the individual.

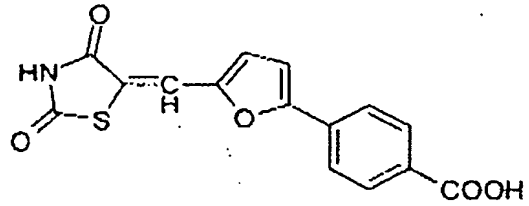
Advantageously, in the process according to the invention, between 5 and 500 μl of a solution or composition as defined above, comprising between 0.001% and 5% of 15-PGDH inhibitor, are applied to the areas of the scalp to be treated.

Implementational examples of the invention will now be given by way of illustration, which examples should in no way limit the scope of the invention.

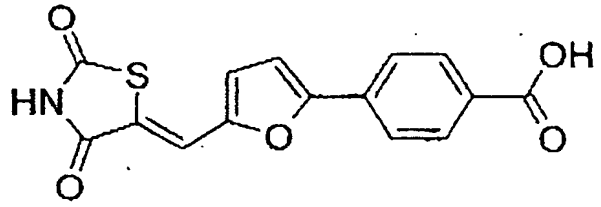
EXAMPLES

Mention may be made, as examples of heterocyclic compounds of formula (I) which can be used in the invention, of the following compounds:

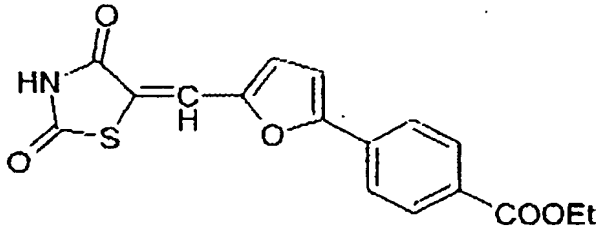
Compound 1: 4-{5-[(2,4-Dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid



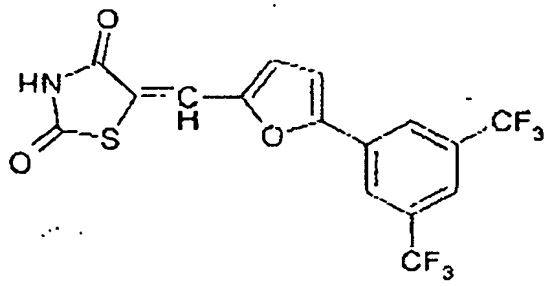
and more specifically the compound 1a:



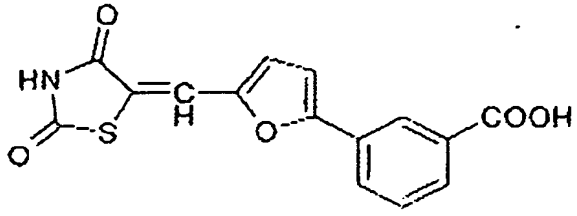
Compound 2: Ethyl 4-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoate



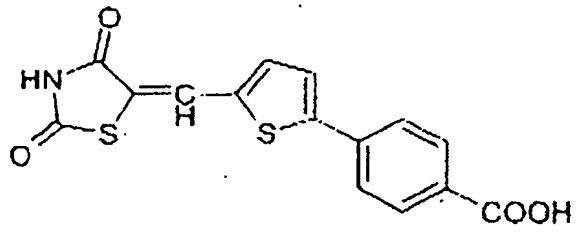
Compound 3: 5-({5-[3,5-bis(Trifluoromethyl)phenyl]-2-furyl}methylene)-1,3-thiazolidine-2,4-dione



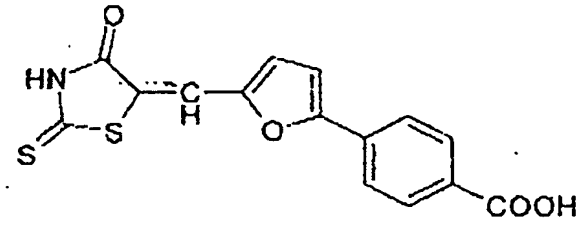
Compound 4: 3-{5-[(2,4-Dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid



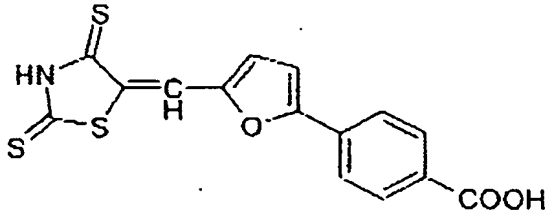
Compound 5: 4-{5-[(2,4-Dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-thiophenyl}benzoic acid



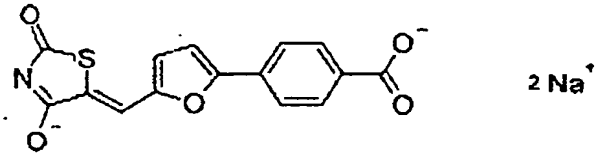
Compound 6: 4-{5-[(2-Sulpho-4-oxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid



Compound 7: 4-{5-[(2,4-Disulpho-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid

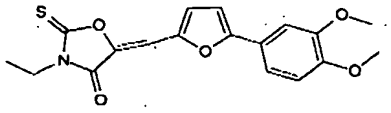


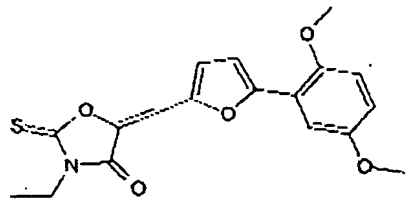
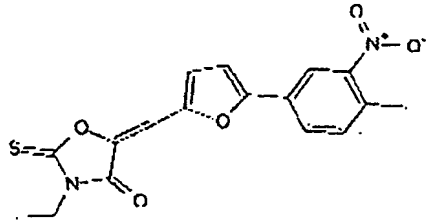
Compound 8: Disodium salt of 4-{5-[(2,4-disulpho-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid (isomer Z):

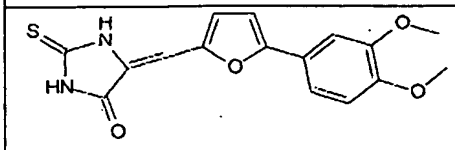
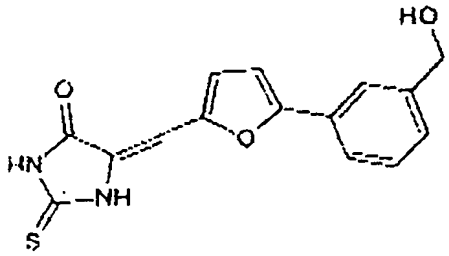
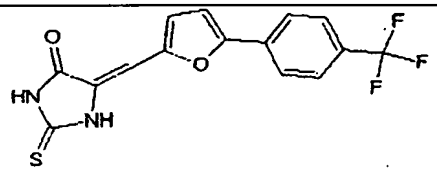


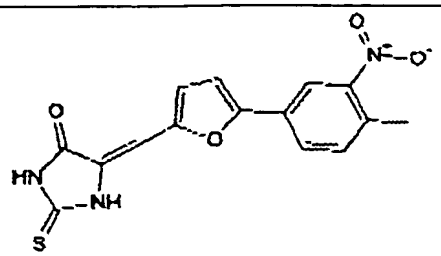
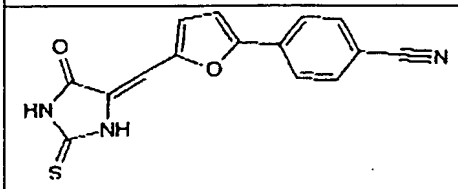
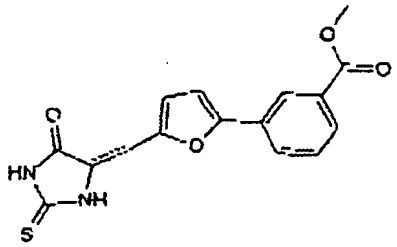
The compound of formula (I) is advantageously the disodium salt of 4-{5-[(2,4-disulpho-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid and in particular the isomer in the Z form.

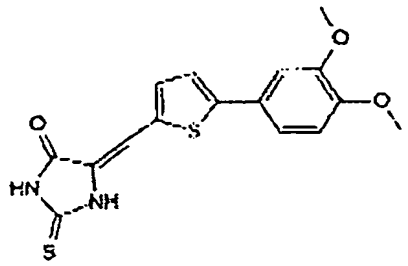
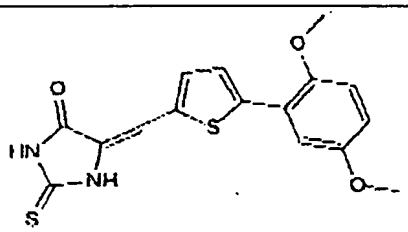
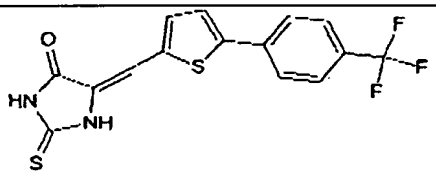
Mention may also be made, as other compounds of formula (I) which can be used in the invention, of:

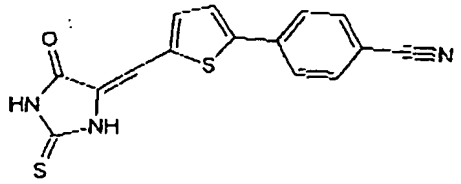
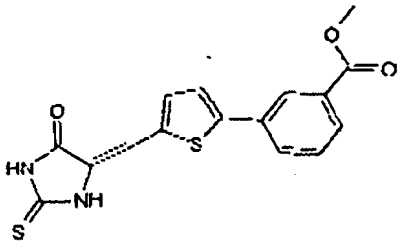
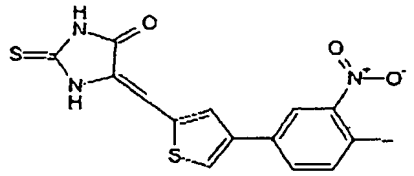
Heterocyclic structure D	**Appear-ance**	**LC purity***	**MS****	**Name**
 Compound D1	russet powder	93	M+H M+Na	5-[5-(3,4-Dimethoxy-phenyl)furan-2-yl-methylene]-3-ethyl-2-

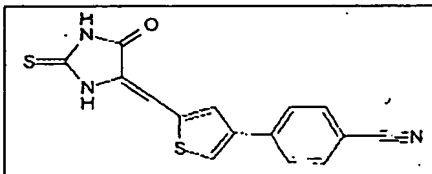
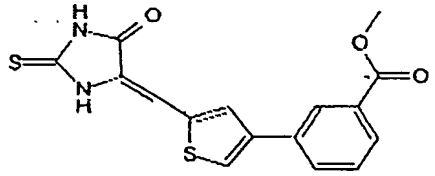
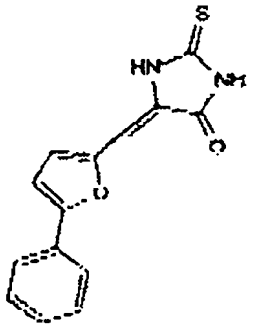
				thioxo-oxazolidin-4-one
 Compound D2	red powder	100	M+Na	5-[5-(2,5-Dimethoxy-phenyl)furan-2-yl-methylene]-3-ethyl-2-thioxo-oxazolidin-4-one
 Compound D3	red powder	100	M-H M+Na	3-Ethyl-5-[5-(4-methyl-3-nitro-phenyl)furan-2-yl-methylene]-2-thioxo-oxazolidin-4-one

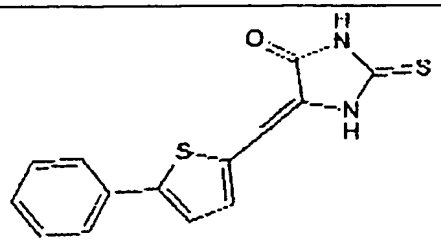
Heterocyclic structure E	App-earance	LC. purity	MS	Name
 Compound E1	red powder	91	M+H M+Na M-H	5-[5-(3,4-Dimethoxy-phenyl)furan-2-yl-methylene]-2-thioxoimidazo-lidin-4-one
 Compound E2	red gum	100	M+H M-H	5-[5-(3-(Hydroxy-methyl)-phenyl)furan-2-yl-methylene]-2-thioxo-imidazolidin-4-one
 Compound E3	orange solid	100	M-H	2-Thioxo-5-[5-(4-(tri-fluoromethyl)-phenyl)-furan-2-yl-methylene]-imidazolidin-4-one

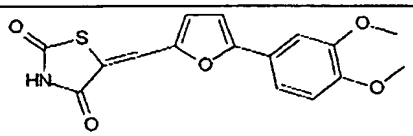
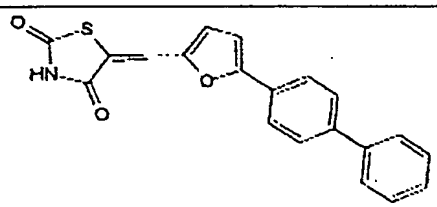
 Compound E4	red powder	73	M-H	5-[5-(4-Methyl-3-nitrophenyl)-furan-2-yl-methylene]-2-thioxo-imidazolidin-4-one
 Compound E5	brown powder	93	M-H	4-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)furan-2-yl]benzo-nitrile
 Compound E6	orange powder	89	M+H M+Na M-H	3-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)furan-2-yl]benzoic acid methyl ester

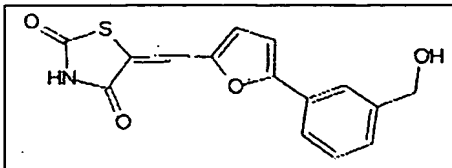
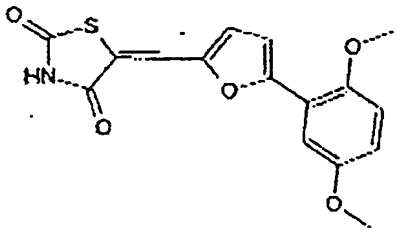
 Compound E7	brown powder	100	M-H	5-[5-(3,4-Dimethoxy-phenyl)thio-phen-2-yl-methylene]-2-thioxo-imidazolidin-4-one
 Compound E8	maroon powder	65	M-H	5-[5-(2,5-Dimethoxy-phenyl)-thiophen-2-ylmethylene]-2-thioxo-imidazolidin-4-one
 Compound E9	orange powder	90	M-H	2-Thioxo-5-[5-(4-(tri-fluoromethyl)-phenyl)thio-phen-2-yl-methylene]-imidazolidin-4-one

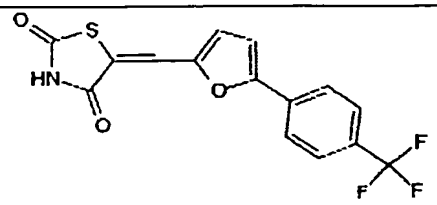
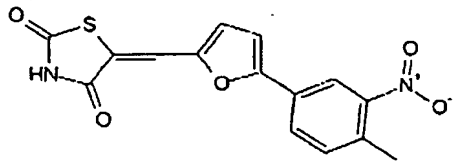
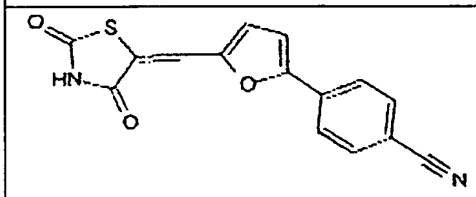
 Compound E10	black powder	66	M-H	4-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)-thiophen-2-yl]benzo-nitrile
 Compound E11	brown powder	90	M-H	3-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)-thiophen-2-yl]benzoic acid methyl ester
 Compound E12	orange powder	64	M-H	5-[4-(4-Methyl-3-nitrophenyl)-thiophen-2-ylmethylene]-2-thioxo-imidazolidin-4-one

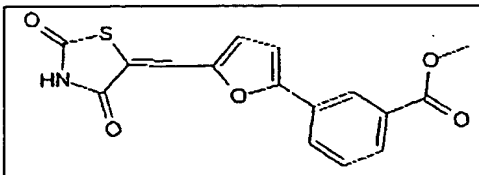
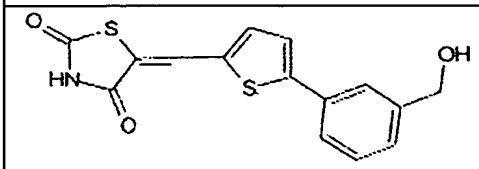
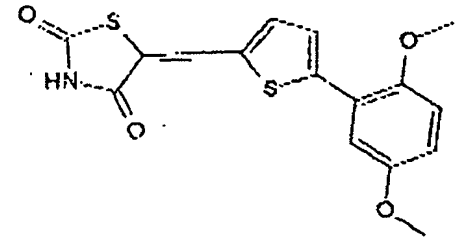
 Compound E13	yellow powder	53	M-H	4-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)-thiophen-3-yl]benzo-nitrile
 Compound E14	yellow powder	91	M-H	3-[5-(5-Oxo-2-thioxo-imidazolidin-4-ylidene-methyl)-thiophen-3-yl]benzoic acid methyl ester
 Compound E15	red gum	100	M-H	5-(5-Phenyl-furan-2-yl-methylene)-2-thioxo-imidazolidin-4-one

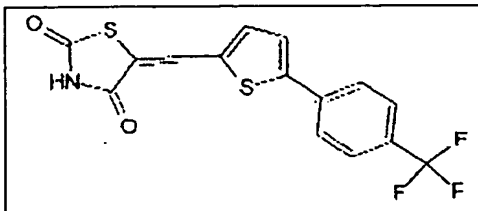
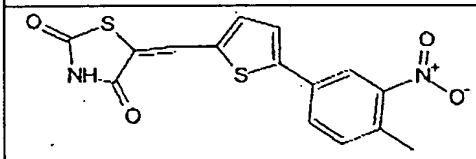
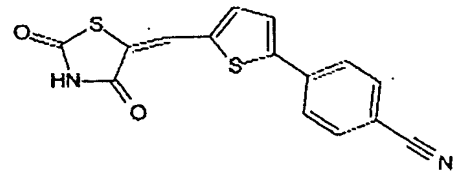
 Compound E16	orange solid	81	M-H	5-(5-Phenyl-thiophen-2-ylmethylene)-2-thioxo-imidazolidin-4-one

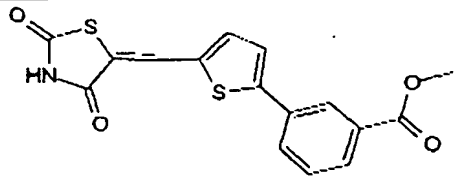
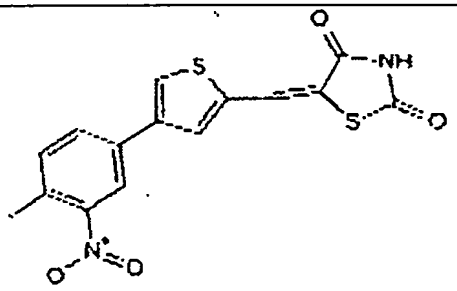
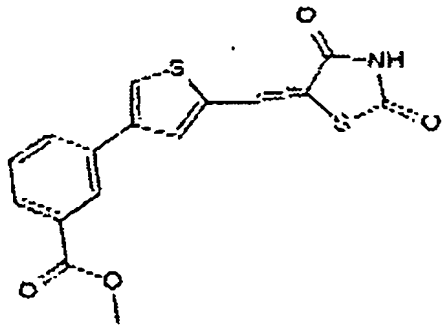
Heterocyclic structure F	**Appea-rance**	**LC purity**	**MS**	**Name**
 Compound F1	orange powder	90	M-H	5-[5-(3,4-Dimethoxy-phenyl)furan-2-ylmeth-ylene]-thiazolidine-2,4-dione
 Compound F2	yellow powder	88	M-H	5-(5-(Biphenyl-4-yl)furan-2-ylmethylene)-thiazolidine-2,4-dione

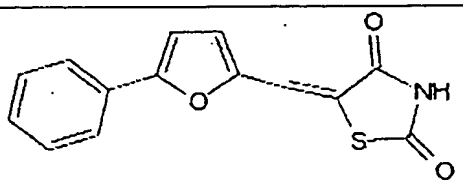
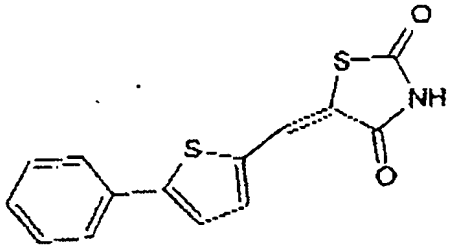
 Compound F3	yellow powder	91	M-H	5-[5-(3-(Hydroxy-methyl)-phenyl)furan-2-yl-methylene]-thiazolidine-2,4-dione
 Compound F4	orange cotton	100.00	M-H	5-[5-(2,5-Dimethoxy-phenyl)furan-2-yl-methylene]-thiazolidine-2,4-dione

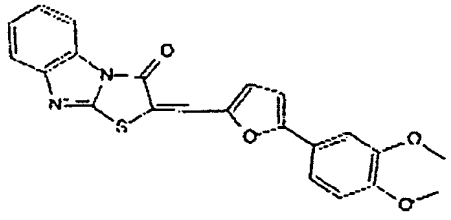
 Compound F5	yellow powder	100	M-H	5-[5-(4-(Trifluoro-methyl)-phenyl)furan-2-yl-methylene]-thiazolidine-2,4-dione
 Compound F6	yellow powder	69	M+Na M-H	5-[5-(4-Methyl-3-nitrophenyl)-furan-2-yl-methylene]-thiazolidine-2,4-dione
 Compound F7	brown gum	100	M-H	4-[5-(2,4-Dioxo-thiazolidin-5-ylidene-methyl)furan-2-yl]benzo-nitrile

 Compound F8	yellow powder	61	M-H	3-[5-(2,4-Dioxo-thiazolidin-5-ylidene-methyl)furan-2-yl]benzoic acid methyl ester
 Compound F9	orange powder	93	M-H	5-[5-(3-(Hydroxy-methyl)-phenyl)-thiophen-2-ylmethylene]-thiazolidine-2,4-dione
 Compound F10	orange powder	59	M-H	5-[5-(2,5-Dimethoxy-phenyl)-thiophen-2-ylmethylene]-thiazolidine-2,4-dione

 Compound F11	red solid	100	M-H	5-[5-(4-(Trifluoro-methyl)phenyl)-thiophen-2-ylmethylene]-thiazolidine-2,4-dione
 Compound F12	russet powder	56	M-H	5-[5-(4-Methyl-3-nitrophenyl)-thiophen-2-ylmethylene]-thiazolidine-2,4-dione
 Compound F13	red powder	41	M-H	4-[5-(2,4-Dioxo-thiazolidin-5-ylidene-methyl)-thiophen-2-yl]benzo-nitrile

 Compound F14	red powder	54	M-H	3-[5-(2,4-Dioxo-thiazolidin-5-ylidene-methyl)-thiophen-2-yl]benzoic acid methyl ester
 Compound F15	orange gum	50	M-H	5-[4-(4-Methyl-3-nitrophenyl)-thiophen-2-ylmethylene]-thiazolidine-2,4-dione
 Compound F16	yellow powder	59	M-H	3-[5-(2,4-Dioxo-thiazolidin-5-ylidene-methyl)-thiophen-3-yl]benzoic acid methyl ester

 Compound F17	yellow flakes	71	M-H	5-(5-Phenyl-furan-2-yl-methylene)-thiazolidine-2,4-dione
 Compound F18	yellow powder	84	M-H	5-(5-Phenyl-thiophen-2-ylmethylene)-thiazolidine-2,4-dione

Heterocyclic structure G	**Appea-rance**	**LC purity**	**MS**	**Name**
 Compound G1	orange powder	62	M+H	2-[5-(3,4-Dimethoxy-phenyl)furan-2-yl-methylene]-benzo[4,5]-imidazo[2,1-b]thiazol-3-one

* LC: Liquid chromatography

** MS: Mass spectrometry

The compounds according to the invention can be synthesized according to the process described below.

General procedure for the synthesis of the compounds with the D, E, F or G structure:

These heterocyclic structures correspond respectively to 3-ethyl-2-thioxo-4-oxazolidinone (CAS number: 10574-66-0, molar mass: 145, structure D), to 2-thiohydantoin (CAS number: 503-87-7, molar mass: 116, structure E), to 2,4-thiazolidinedione (CAS number: 2295-31-0, molar mass: 117, structure F) and to thiazolo[2,3-b]benzimidazole-3(2H)-one (CAS number: 3042-01-1, molar mass: 190, structure G).

100 mg of aldehyde, 1 equivalent of heterocycle of structure D, E, F or G, 20 µl of piperidine and then 1.5 ml of absolute ethanol are introduced into a Pyrex® reaction tube of the synthesis system under Discover microwave irradiation from STEM.

The tube is equipped with a magnetic bar and then closed by a crimped stopper.

The reaction medium is subsequently irradiated in the Discover device according to the following parameters:

- Power released: 250 W
- Set temperature: 150°C
- Irradiation time: 2 minutes
- Maximum time to reach the set [lacuna]: 4 minutes.

After cooling, the reaction medium is filtered through a sintered glass filter and the solid

is washed with the minimum amount of absolute ethanol and then dried under vacuum.

Yield: 40-100%

The samples are analysed by LC-UV-MS according to the following conditions:

Gradient: acetonitrile 10/water 90 to acetonitrile 90/ water 10 in 8 minutes

Column: X-terra_MS C18 3.5 μm 3 × 50 mm

Flow rate: 0.5 ml/min

UV: linear array of 290 nm-450 nm diodes

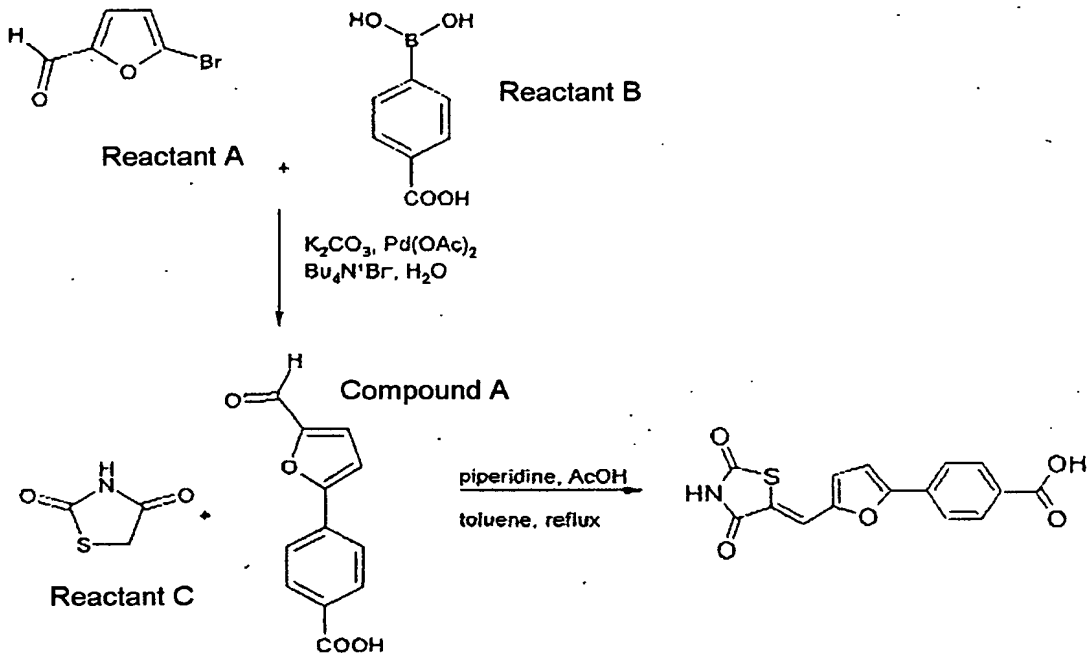
MS: Electrospray with ionization at positive and negative atmospheric pressure.

The reaction scheme of Compounds 1, 3, 4 and 8 is given below by way of example.

EXAMPLE 1: Compound 1

Preparation of 4-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid

Reaction scheme



Procedure

Stage 1

1.99 g (6.16 mmol) of tetrabutylammonium bromide are dissolved in 100 ml of water in a 50 ml three-necked round-bottomed flask equipped with a cooling system and a magnetic stirrer and then 1.12 g (6.7 mmol) of 4-carboxyphenylboronic acid (reactant B), 1.08 g (6.16 mmol) of 5-bromo-2-furaldehyde (reactant A), 30 mg (2 mol%) of palladium acetate and 2.12 g (15.4 mmol) of potassium carbonate are introduced. The reaction medium is left at ambient temperature (20-25°C) for 12 hours. The mixture is subsequently washed with ethyl acetate (3 times with 50 ml). The aqueous phase is acidified to pH = 1-2 with

a 35% hydrochloric acid solution. The yellow-beige solid formed (compound A) is filtered off, then rinsed with water (3 times with 20 ml) and dried under vacuum in the presence of 1.2 g of phosphorus pentoxide. The reaction yield is 90%.

Stage 2

0.38 g (3.25 mmol) of thiazolidin-2,4-dione is dissolved in 20 ml of toluene in a 50 ml three-necked round-bottomed flask equipped with a Dean and Stark apparatus, a thermometer and a magnetic stirrer and then 0.7 g (3.25 mmol) of yellow-beige solid formed above (compound A) is introduced. 0.15 ml of acetic acid and 0.15 ml of piperidine are subsequently added and then the mixture is brought to reflux for 5 hours. A yellow solid is formed and is filtered off and then rinsed with toluene (2 times with 20 ml). The product is then dried under vacuum in the presence of 0.85 g of phosphorus pentoxide. The crude reaction yield is 78%.

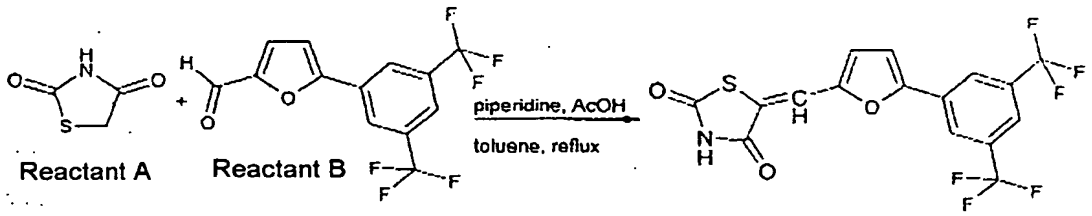
Analysis

Nuclear Magnetic Resonance: The spectrum obtained is in agreement with the structure proposed.

EXAMPLE 2: Compound 3

Preparation of 5-({5-[3,5-bis(trifluoromethyl)phenyl]-2-furyl}methylene)-1,3-thiazolidine-2,4-dione

Reaction scheme



Procedure

0.38 g (3.25 mmol) of thiazolidin-2,4-dione (reactant A) is dissolved in 20 ml of toluene in a 50 ml three-necked round-bottomed flask equipped with a Dean and Stark apparatus, a thermometer and a magnetic stirrer and then 1 g (3.25 mmol) of 5-[3,5-bis(trifluoromethyl)phenyl]-2-furaldehyde (reactant B) is introduced. 0.15 ml of acetic acid (AcOH) and 0.15 ml of piperidine are subsequently added and then the mixture is brought to reflux for 5 hours. A yellow solid was formed during the reaction. It is filtered off, then rinsed with toluene (2 times with 20 ml) and dried under vacuum in the presence of 0.86 g of phosphorus pentoxide. The reaction yield is 65%.

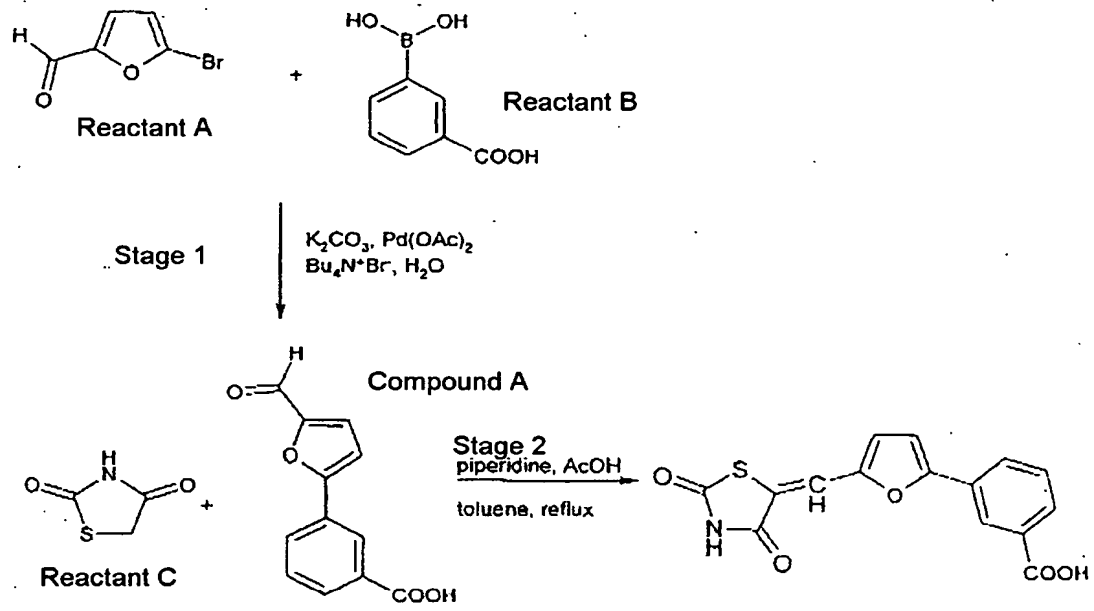
Analysis

- *Mass spectrometry*: The quasimolecular ion (M-H)- of the expected molecule, $C_{16}H_7F_6NO_3S$, is mainly detected.
- *Nuclear Magnetic Resonance*: The spectrum obtained is in agreement with the structure proposed.

EXAMPLE 3: Compound 4

Preparation of 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid

Reaction scheme



Procedure

Stage 1

1.99 g (6.16 mmol) of tetrabutylammonium bromide are dissolved in 100 ml of water in a 50 ml three-necked round-bottomed flask equipped with a cooling system and a magnetic stirrer and then 1.12 g (6.7 mmol) of 3-carboxyphenylboronic acid (reactant B), 1.08 g (6.16 mmol) of 5-bromo-2-furaldehyde (reactant A), 30 mg (2 mol%) of palladium acetate and 2.12 g (15.4 mmol) of potassium carbonate are introduced. The reaction medium is left at ambient temperature (20-25°C) for 12 hours. The mixture is subsequently washed with ethyl acetate (3 times with 50 ml). The aqueous phase is acidified to pH = 1-2 with an aqueous hydrochloric acid solution: 35%. The pinkish-beige solid formed (compound A) is filtered off, then rinsed

with water (3 times with 20 ml) and dried under vacuum in the presence of 1.1 g of phosphorus pentoxide. The reaction yield obtained is 82%.

Stage 2

0.542 g (4.62 mmol) of thiazolidin-2,4-dione is dissolved in 20 ml of toluene in a 50 ml three-necked round-bottomed flask equipped with a Dean and Stark apparatus, a thermometer and a magnetic stirrer and then 1 g (4.62 mmol) of the pinkish-beige solid formed above (compound A) is introduced. 0.15 ml of acetic acid (AcOH) and 0.15 ml of piperidine are subsequently added and then the mixture is brought to reflux for 5 hours. The formation of a yellow solid is observed, which solid is filtered off and then rinsed with toluene (2 times with 20 ml). The solid is subsequently dispersed in 100 ml of water. A 2N aqueous sodium hydroxide solution is then added until the product has completely dissolved and then acidification is carried out with a 1N aqueous hydrochloric acid solution until a pH of 1-2 is reached. The brown solid formed is filtered off, then washed with water (2 times with 50 ml) and dried under vacuum in the presence of 0.86 g of phosphorus pentoxide. The yield is 63%.

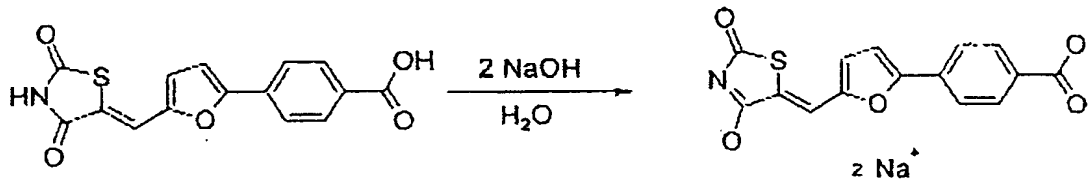
Analysis

Nuclear Magnetic Resonance: The spectrum obtained is in agreement with the structure proposed.

EXAMPLE 4: Compound 8

Preparation of the disodium salt of 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid

Reaction scheme



Procedure

15 g of 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid are dissolved in 500 ml of an aqueous sodium hydroxide solution (2 equivalents). This solution is washed with 2 times 50 ml of dichloromethane and then partially concentrated. This solution is then run onto acetone. 11 g of an orange-yellow precipitate, corresponding to the disodium salt of 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-2-furyl}benzoic acid, in the Z form, are thus obtained.

Analysis

Nuclear Magnetic Resonance: The spectrum obtained is in agreement with the structure proposed.

EXAMPLE 5: Demonstration of the specific inhibitory properties with respect to 15-PGDH of the compounds of formula (I).

1) Test on 15-PGDH

The enzyme 15-PGDH is obtained as disclosed in Application FR-A-02/05067, filed on behalf of

L'Oréal, in suspension in a suitable medium at a concentration of 0.3 mg/ml, then blocked at -80°C. For the requirements of the test, this suspension is defrosted and stored in ice.

Furthermore, a Tris 100 mM, pH = 7.4, buffer comprising 0.1 mM of dithiothreitol (D5545, Sigma-Aldrich, L'isle D'Abeau Chesne, BP 701, 38297, Saint Quentin Fallavier), 1.5 mM of β-NAD (N6522, Sigma-Aldrich, L'isle D'Abeau Chesne, BP 701, 38297, Saint Quentin Fallavier) and 50 μM of prostaglandin E_2 (P4172, Sigma-Aldrich, L'isle D'Abeau Chesne, BP 701, 38297, Saint Quentin Fallavier) is prepared.

0.965 ml of this buffer (brought beforehand to 37°C) is introduced into the cell of a spectrophotometer (Perkin-Elmer, Lambda 2) thermostatically controlled at 37°C, the wavelength of which for the measurement is adjusted to 340 nm. 0.035 ml of enzymatic suspension at 37°C is introduced into the cell concomitantly with the recording (corresponding to an increase in optical density at 340 nm). The maximum rate of reaction is noted.

The test values (comprising the compounds (I)) are compared with the control value (without compound (I)); the results indicated represent the concentration at which the compound (I) inhibits 50% of the enzymatic activity of 15-PGDH, referred to as IC_{50}dh.

2) Test on PGFS

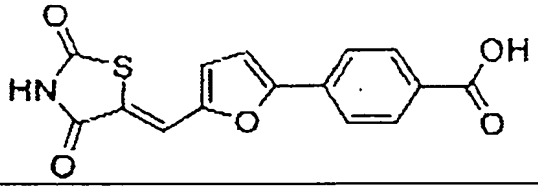
The enzyme PGF synthase is obtained as disclosed in the document FR-A-02/05067, at a concentration of 0.5 mg/ml, in suspension in an appropriate medium, and is blocked at -80°C. For the requirements of the test, this suspension is defrosted and stored in ice.

Furthermore, a Tris 100 mM, pH = 6.5, buffer comprising 20 μM of 9,10-phenanthrenequinone* (P2896, Sigma-Aldrich, L'isle D'Abeau Chesne, BP 701, 38297, Saint Quentin Fallavier) and 100 μM of β-NADPH (N1630, Sigma-Aldrich, L'isle D'Abeau Chesne, BP 701, 38297, Saint Quentin Fallavier) is prepared in a brown bottle (exclusion of light).

* A mother solution assaying 1 mM is prepared in absolute ethanol and is brought to 40°C; the bottle is placed in an ultrasonic bath to facilitate the dissolution of the product.

0.950 ml of this buffer (brought beforehand to 37°C) is introduced into the cell of a spectrophotometer (Perkin-Elmer, Lambda 2) thermostatically controlled at 37°C, the wavelength of which for the measurement is adjusted to 340 nm. 0.05 ml of enzymatic suspension at 37°C is introduced into the cell concomitantly with the recording (corresponding to a fall in optical density at 340 nm). The maximum rate of reaction is noted.

The test values (comprising the compound (I)) are compared with the control value (without compound (I)); the results indicated represent the concentration at which the compound (I) inhibits the enzymatic activity of PGFS by 50%, referred to as $IC_{50}fs$.

Compound	Structure	Inhibition of 15-PGDH $IC_{50}dh$ (μM)	Inhibition of PGFS $IC_{50}fs$ (μM)
1		0.3	4

It emerges from this table that the ratio $IC_{50}fs/IC_{50}dh$ of Compound 1 is greater than 13. Compound 1 therefore clearly has an inhibitory activity with respect to 15-PGDH and in particular an activity which is selective with respect to PGFS.

The compositions below are obtained by the usual techniques commonly used in the cosmetic or pharmaceutical field.

EXAMPLE 6: Hair lotion

- Compound 1 0.80 g
- Propylene glycol 10.00 g
- Isopropyl alcohol q.s. for 100.00 g

This lotion is applied to the scalp one or two times daily at the rate of 1 ml per application, the scalp being lightly massaged to bring about the

penetration of the active principle. The hair is subsequently dried in the open air. This lotion makes it possible to reduce hair loss and to promote hair regrowth.

EXAMPLE 7: Hair lotion

- Compound 2		1.00	g
- Propylene glycol		30.00	g
- Ethyl alcohol		40.00	g
- Water	q.s. for	100.00	g

This lotion is applied to the scalp one or two times daily at the rate of 1 ml per application, the scalp being lightly massaged to bring about the penetration of the active principle. The hair is subsequently dried in the open air.

EXAMPLE 8: Hair lotion

- Compound 1		1	g
- Ethyl alcohol		40.00	g
- NaOH	q.s. for	(*)	
- Water	q.s. for	100.00	g

(*) amount sufficient to neutralize the acid functional group carried by the phenyl ring (R_1)

This lotion is applied to the scalp one or two times daily at the rate of 1 ml per application, the scalp being lightly massaged to bring about the penetration of the active principle.

EXAMPLE 9: Demonstration of the specific inhibitory effectiveness for 15PGDH on a cell model.

The present study is targeted at evaluating the compounds of formula (I) in a cell model. This study makes it possible to determine the penetration of the active principle into the cytosol and its effectiveness as specific inhibitor of 15-PGDH under more complex experimental conditions than a simple reaction medium.

Equipment and methods

D-2. Culturing of U937 (CRL-1593 American Type Cells Collection) in RPMI medium 1640 + 10% of foetal calf serum + 2 mM of L-glutamine + antibiotics at 37°C under 5% of CO_2.

D-1. Preparation of a suspension of U937 (1×10^6 cells/ml) in RPMI medium 1640 + 10% of foetal calf serum + 2 mM of glutamine + antibiotics + 10 nM of PMA (phorbol 12-myristate 13-acetate); introduction of 200 μl per test well of this suspension into a 96-well plate (3 wells per molecule and per concentration to be tested + corresponding controls); incubation at 37°C for 36 h 00 under 5% CO_2.

D0. Removal of the supernatants (the cells have adhered to the bottom of the wells: monitoring using a microscope) and introduction into each well of 100 μl of RPMI 1640 + 2 mM of L-glutamine + 10 ng of LipoPolySaccharide (LPS) (except absolute control) + the test molecule at the desired concentration (in this instance, 5 and 25 μM).

Incubation at 37°C for 6 h 00 under 5% of CO_2.

The mother solutions of test molecules are at 25 mM in DiMethyl SulfOxide.

All the wells comprise the same final amount of DMSO.

Immediate evaluation of the amount of $PGF_{2\alpha}$ secreted by the cells (50 μl) under the various conditions (molecules or controls) by the use of an immuno-enzymatic assay kit (Cayman, Ref. 516011).

Results below as % of the LPS control.

Reference Molecule (5 μM)	% of the control
Compound 1:	+76 ± 20
Compound 8:	+44 ± 16

This confirms that the compounds according to the invention are selective inhibitors of 15-PGDH in a cell environment and protect prostaglandins.

EXAMPLE 10: Hair lotion

- Compound 8		1	g
- Ethyl alcohol		40.00	g
- Propylene glycol		30.00	g
- Water	q.s. for	100.00	g

EXAMPLE 11: Wax/water mascara

- Beeswax	6.00	%
- Paraffin wax	13.00	%
- Hydrogenated jojoba oil	2.00	%
- Water-soluble film-forming polymer	3.00	%
- Triethanolamine stearate	8.00	%

- Compound 5		1.00	%
- Black pigment		5.00	%
- Preservative	q.s.		
- Water	q.s. for	100.00	%

This mascara is applied to the eyelashes like a conventional mascara with a mascara brush.

EXAMPLE 12: Hair lotion

- Compound 8		0.10	g
- Latanoprost		0.10	g
- Propylene glycol		30.00	g
- Ethyl alcohol		40.00	g
- Water	q.s. for	100.00	g

EXAMPLE 13: Hair lotion

- Compound 8		1	%
- Ethyl alcohol		49.5	%
- Water	q.s. for	100	%

This lotion is applied to the scalp one or two times daily at the rate of 1 ml per application, the scalp being lightly massaged to bring about the penetration of the active principle. The hair is subsequently dried in the open air. This lotion makes it possible to reduce hair loss and to promote hair regrowth. It also makes it possible to improve the appearance of the hair.